

### Tropical Meteorology – Homework #3

**Due Date:** 10 March 2016

1. For this question, please use the Hovmöller plots available on the course website at <http://derecho.math.uwm.edu/classes/TropMet/assignments/HW-EW/>. There are a total of twenty-one images in this directory, encompassing the period from 1 April 2011 to 11 February 2016. Images are numbered sequentially in time. All images are courtesy Carl Schreck's webpage at <http://monitor.cicsnc.org/mjo/v2/>.

On these images, outgoing longwave radiation anomalies averaged between 7.5°S and 7.5°N are shaded per the color bar at the bottom of each image. Negative (positive) values indicate enhanced (suppressed) convective activity. Blue contours denote outgoing longwave radiation anomalies associated with the Madden-Julian Oscillation (MJO). Enhanced (suppressed) convection is denoted by solid (dashed) contours; where concentric contours exist, convection is particularly enhanced or suppressed.

- a. (5 pts) Over what range of longitudes are the convectively-enhanced and convectively-suppressed phases of the MJO most commonly found?
  - b. (5 pts) During what times of the year is the MJO most and least active?
  - c. In a review of the synoptic- to sub-seasonal effects of the Madden-Julian Oscillation, Zhang (2013, *Bull. Amer. Meteor. Soc.*) states that “[recent] major ENSO warming events (El Niño) were preceded by extraordinarily strong episodes of the MJO.”
    - i. (15 pts) Based upon what you know about the structure of the MJO and how El Niño events form, discuss why this statement may be true.
    - ii. (15 pts) The first nine months of 2015 featured the development of a strong El Niño event. To what extent is the statement above supported by the Hovmöller plots? Describe.
    - iii. (15 pts) Just as the MJO may influence ENSO, it is believed that ENSO may influence the MJO. Consider the periods 1 July 2011-31 January 2012 (La Niña) and 1 March 2015-11 February 2016 (El Niño). Describe differences in the MJO (occurrence, intensity, and eastward extent, if such differences are evident) between these periods. Hypothesize why these differences exist.
2. Rossby wave trains emanating from areas of enhanced convection associated with the MJO can exert an influence upon mid-latitude weather. The [Climate Prediction Center's](#) website contains plots of three-month-averaged surface temperature anomalies over the

continental United States for each MJO phase. Each figure contains sixteen panels. In the leftmost eight panels, the surface temperature anomalies ( $^{\circ}\text{C}$ ) for each MJO phase are plotted. In the rightmost eight panels, statistical significance of the surface temperature anomalies for each MJO phase is plotted, with medium blue to purple shading indicating statistically-significant temperature anomalies to  $\geq 90\%$  confidence.

- a. (5 pts) Click on “FMA,” for February, March, and April. Consider the western Great Lakes and Upper Midwest. Which MJO phases have statistically-significant cold anomalies? Which have statistically-significant warm anomalies?
- b. (10 pts) The [Bureau of Meteorology](#) maintains archived MJO phase space data. In these data, the first three columns indicate the year, month, and date, respectively. The fourth and fifth columns denote the daily value of RMM1 and RMM2 from the Wheeler and Hendon (2004) MJO phase space. Save the data for 6-28 March 2012 into a text file. Create a line scatterplot of RMM1 ( $x$  axis, -4 to +4) versus RMM2 ( $y$  axis, -4 to +4) using your favorite plotting software. Please label each axis. Indicate which ends of your line correspond to 6 and 28 March.
- c. (10 pts) The [NCEP/NCAR Reanalysis](#) plotted from NOAA/ESRL/PSD can be used to obtain daily mean composites of a wide range of atmospheric fields. Use this tool to obtain a plot of *anomalous surface temperature* for the period 6-28 March 2012 over the United States, including state borders.
- d. (10 pts) Using your result to (b), compare your plot from (c) to that from (a). Does evidence exist to support the hypothesis that the observed surface temperature anomalies for 6-28 March 2012 resulted in whole or in part from the MJO? Why?
- e. (10 pts) Repeat (b) and (c) for 23 February-6 March 2014, and include each plot with your completed assignment. Does evidence exist to support the hypothesis that the observed surface temperature anomalies for 23 February-6 March 2014 resulted in whole or in part from the MJO? Why?